Unit-2 (Nuclear Physics)

① Nuclear reaction

(*) Write down the quantities which are conserved in nuclear reaction?

→ (i) The mass no. should be conserved and Proton no. should be conserved.

(ii) Momentum should be conserved.

(iii) Mass - Energy should be conserved.

(iv) charge should be conserved

(*) (i) What do you mean by Q-value of Nuclear reaction?

(ii) what is Endo-thermic and Exothermic Nuclear reaction?

→ (i) The amount of Energy released or absorb in a nuclear reaction, is known as Q-value of nuclear reaction.

If Energy is absorb in a nuclear reaction, then it is known as endothermic Reaction.

The Q-value is negative in this case.

If Energy is release in a nuclear reaction, then it is known as Exothermic Reaction.

The Q-value is +ve in this case.

Q-value = KE of Product - KE of reactant.

(*) Find the Expression for Q-value in terms of mass of the reactant, mass of the Product. Hence find the Expression for Q-value in terms of Binding energy of Product and reactant?

→

$$X + x \longrightarrow Y + y$$

$$M_x + m_x \longrightarrow M_y + m_y$$

Reactant Product.

Here, M_X = Rest mass of nucleus 'X'.

m_x = " " " " 'x'

M_Y = " " " " 'Y'

m_y = " " " " 'y'

using Mass-Energy conservation,

$$M_X c^2 + T_X + m_x c^2 + T_x = M_Y c^2 + T_Y + m_y c^2 + T_y$$

$$\Rightarrow (T_Y + T_y) - (T_X + T_x) = (M_X + m_x) c^2 - (M_Y + m_y) c^2 \quad \text{(1)}$$

T_X = KE of nucleus X

T_x = " " 'x'

T_Y = " " 'Y'

T_y = " " 'y'

$\Rightarrow$ (Mass of Reactant - mass of Product) c^2 = KE of Product - KE of reactant

$\Rightarrow$ Q-value = (Mass of reactant - Mass of Product) c^2

$$_{Z_1}X^{A_1} + _{Z_2}x^{A_2} \longrightarrow _{Z_3}Y^{A_3} + _{Z_4}y^{A_4}$$

$$A_1 + A_2 = A_3 + A_4$$

$$Z_1 + Z_2 = Z_3 + Z_4$$

B.E. of $X = \{Z_1 m_p + (A_1 - Z_1) m_n - M_X\} c^2$

B.E. of $x = \{Z_2 m_p + (A_2 - Z_2) m_n - m_x\} c^2$

B.E. of $Y = \{Z_3 m_p + (A_3 - Z_3) m_n - M_Y\} c^2$

B.E. of $y = \{Z_4 m_p + (A_4 - Z_4) m_n - m_y\} c^2$

$\therefore$ BE Product − B.E. of Reactant

$= BE\,Y + BE\,of\,y - BE\,of\,X - BE\,of\,x$

$= [(Z_3 + Z_4) m_p + (A_3 + A_4 - Z_3 - Z_4) m_n - M_Y - m_y - (Z_1 + Z_2) m_p - (A_1 + A_2 - Z_1 - Z_2) m_n + M_X + m_x] c^2$

$= [0 \times m_p + 0 \cdot m_n + M_X + m_x - M_Y - m_y] c^2$

$= (M_X + m_x) c^2 - (M_Y + m_y) c^2$

$\therefore$ $\boxed{\text{Q-value} = \text{BE Product} - \text{BE Reactant}}$

(*) what do you mean by threshold KE?

→ the minimum KE of Projectile required in endothermic nuclear reaction is known as threshold Kinetic Energy.

For Example -

$$x + X \xrightarrow{-W} y + Y$$

Energy absob (endothermic reaction)

x → Projectile, X → Target

let, the mass of the nucleus 'X' = M_X

" " " " Particle 'x' = m_x

the threshold KE, in this case -

$$K_{th} = -Q\left(1 + \frac{m_x}{M_X}\right), \quad Q = Q\text{-value of the nuclear reaction.}$$

(*) calculate, the Q-value of the following reaction?

$${}_1H^2 + {}_{29}Cu^{63} \longrightarrow {}_0n^1 + {}_{30}Zn^{64}$$

$M({}_1H^2) = 2.014102$ amu. $M({}_{29}Cu^{63}) = 62.929599$ amu

$M({}_0n^1) = 1.008665$ amu. $M({}_{30}Zn^{64}) = 63.929142$ amu

If the KE of ${}_1H^2$ is 12 Mev incident on Cu at rest, the KE of ${}_0n^1$ is 16.85 Mev. Find the KE of Zn.

→ $Q = [0.005894]$ amu $\times c^2$ | 1 amuc^2 = 933 Mev

$= 5.499102$ Mev.

again, q value = KE of Product − KE of reactant

$\Rightarrow 5.499102 = 16.85 + KE_{2n} - 12$

$\Rightarrow KE_{2n} = 0.649102$ Mev.

(*) calculate the threshold KE for the following reaction?

$$ {}_1p^1 + {}_1H^3 \rightarrow {}_1H^2 + {}_1H^2 $$

(i) If the Proton incident on ${}_1H^3$.

(ii) if the ${}_1H^3$ " " ${}_1p^1$.

$M({}_1P^1) = 1.007825$ amu, $M({}_1H^3) = 3.016049$ amu

$M({}_1H^2) = 2.014102$ amu

$\Rightarrow Q = (4.028204 - 4.023874)$ amu $\times c^2$

$= -0.00433$ amu $\times c^2$

$= -4.03989$ Mev.

(i) $K_{th} = 4.03989\,(1 + 0.3341548)$

$= 5.38983$ Mev.

(ii) $K_{TH} = 4.03989\,(1 + 2.992542)$

$= 16.129432$ Mev.

α - Particle

Q.) Find and Expression for Q-value in α-disintegration of nucleus ?

ii) S.T in α- disintegration Maximum Energy of the reaction is carrid out by the α- Particle ?

→ (i) We consider, a nucleus X emit's an α-Particle from rest ..

$$ {}_{Z}X^{A} \longrightarrow {}_{Z-2}Y^{A-4} + \alpha $$

(Parent nucleus) (Daughter nucleus)

the mass of the nucleus $X = M_X$ and and the mass of the nucleus $Y = M_Y$, Mass of the α-Particle $= M_\alpha$

the Q - Value of the reaction,

$$ Q = \text{KE of Product} - \text{KE of reactant} $$

$$ = \frac{1}{2} M_Y V_Y^2 + \frac{1}{2} M_\alpha V_\alpha^2 - 0 $$

$$ = \frac{1}{2} M_Y V_Y^2 + \frac{1}{2} M_\alpha V_\alpha^2 \longrightarrow (1) $$

V_Y = Velocity of Nucleus 'Y'

V_α = Velocity of nucleus α

using Momentum Conservation,

$$ 0 = M_\alpha V_\alpha + M_Y V_Y $$

$$ \Rightarrow V_Y = -\frac{M_\alpha V_\alpha}{M_Y} \longrightarrow (ii) $$

Using (ii) in (1).

$$ Q = \frac{1}{2} M_Y \frac{M_\alpha^2 V_\alpha^2}{M_Y^2} + \frac{1}{2} M_\alpha V_\alpha^2 $$

$$= \frac{1}{2} M_\alpha V_\alpha^2 \left[1 + \frac{M_\alpha}{M_Y} \right]$$

$$\Rightarrow \frac{1}{2} M_\alpha V_\alpha^2 = \frac{Q}{1 + \frac{M_\alpha}{M_Y}}$$

$$\Rightarrow \text{KE of } \alpha\text{-Particle} = \frac{M_Y}{M_\alpha + M_Y} \cdot Q$$

Mass of nucleus $\propto$ Mass no.

$M_Y = A-4$, $M_\alpha = 4$.

$$\therefore \boxed{\text{KE of } \alpha = \frac{A-4}{A} Q}$$

this is the expression for KE of α-Particle emits from a nucleus of Mass no. A.

if $A \gg 4$, the maximum Energy of α- disintegration is carried out by the α- Particle.

(*) The Q-value of α- disintegration from $_{92}U^{235}$ is 12 Mev. Find the KE of α Particle and Daughter nucleus!

$\rightarrow$ $Q = 12$ Mev.

$$KE|_\alpha = \frac{231}{235} \times 12 = 11.795 \text{ Mev}.$$

$$KE|_Y = \frac{4}{A} Q = \frac{4}{235} \times 12 = 0.204 \text{ Mev}$$

(*) (i) what do you mean by range of α-Particle?
(ii) State the factor on which range of α-Particle?

→ (i) the distance through which α-Particle travel's in a specific medium before stoping to ionize the medium is known as range of α-Particle.

(ii) the range of α-Particle depend's on following factor's —

① the initial energy of α-Particle :-
the greater the initial energy of α-Particle the greater the range of α-Particle.

② Ionization Potential of the gas :-
the range of α-Particle is inversely Proportional to ionization energy of the gas.

③ The range of α-Particle is inversely Proportional to density of the medium.

④ With the increasing Pressure, range of α-Particle decreases. with the increase of temp. the range of α-Particle increase's.

(*) State and Prove geiger's law for the range of α-Particle?

→ According to Geiger's law the range of α-Particle is ~~inversely~~ Proportional to Cube of initial velocity of α-Particle.

i.e. $R \propto v^3$; where,
R = Range of α-particle
v = initial velocity of α-particle

Proof:

the decreasing KE of α particle per unit length is inversely proportional to its velocity.

i.e. $\frac{dE}{dx} \propto -\frac{1}{v}$

$\Rightarrow \frac{dE}{dx} = -\frac{a}{v}$; $E = \frac{1}{2}mv^2$ (1)

$\Rightarrow \frac{1}{\cancel{2}} m \cancel{2} v \frac{dv}{dx} = -\frac{a}{v}$

$\Rightarrow v^2 dv = -\frac{a}{m} dx$

integrating both side :

$\int_{v_0}^{0} v^2 dv = -\frac{a}{m} \int_0^R dx$, v_0 = initial velocity
R = Range of α-particle

$\Rightarrow \left[\frac{v^3}{3}\right]_{v_0}^{0} = -\frac{a}{m} R$

$\Rightarrow \cancel{-}\frac{v_0^3}{3} = \cancel{+}\frac{a}{m} R$

$\therefore \boxed{R \propto v_0^3}$

this is known as geiger's law.

(*) i) State Geiger-Nuttal Law for the range of α-Particle?

ii) Find the relation between Range of α-Particle and decay const. of radioactive nucleus?

→

(i) → Geiger and Nuttal showed that, the range of α-Particle in air medium and the disintegration const. of Parent nucleus from which α-Particle is Emitted, is connected by a Simple relation called Geiger-Nuttal law.

(ii) → the empirical expression of Geiger-Nuttal law,

$$\log_e \lambda = A + B \log_e R,$$

where, λ = disintegration const.

R = range of α-Particle.

again, $T_{1/2}$ (Half Life) $= \frac{0.693}{\lambda}$

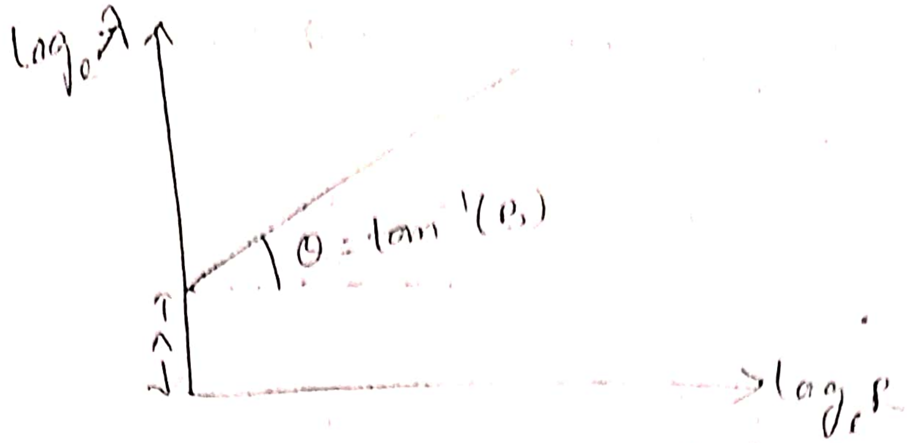
$$\Rightarrow \lambda = \frac{0.693}{T_{1/2}}$$

$$\log_e \left\{ \frac{0.693}{T_{1/2}} \right\} = A + B \log_e R$$

$$\Rightarrow \log_e 0.693 - \log_e T_{1/2} = A + B \log_e R.$$

$$\Rightarrow \boxed{-\log_e T_{1/2} = A' + B \log_e R}$$

This is the relation between Range of α-Particle and the Half life of the nucleus from which the α-Particle was emitted.



(iii) Find the Coulomb Potential of the nucleus U^{235}_{92} (ii) Find the interaction energy, when a α-Particle is emitted from the nucleus ?

→ (i) for U^{235}_{92}, $Z = 92$

radius of the nucleus, $R = R_0 A^{1/3}$

$R_0 = 1.3 \text{ fm}$

$R = 1.3 \times 10^{-15} (235)^{1/3} \text{ m}$

$R = 8.02 \times 10^{-15} \text{ m}$

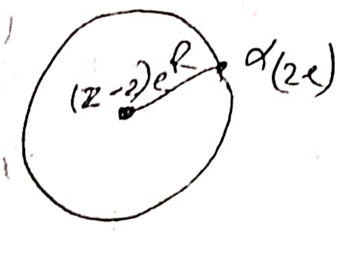
Coloumb Potential on the surface of nucleus, $V = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{R}$

$= 9 \times 10^{9} \times \frac{92 \times 10^{-19} \times 1.6}{8.02 \times 10^{-15}} \text{ J/C}$

$= 165.187 \times 10^{5} \text{ J/C}$

(ii) The interaction Energy when a α-particle is emitted from the nucleus of U^{235}_{92}

The interaction energy,



$$V = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{R}$$

$$= 9\times10^{9} \times \frac{2e\,(Z-2)e}{R}$$

$$= 9\times10^{9} \times \frac{2\times90\times(1\cdot6)^{2}\times10^{-38}}{8\cdot02\times10^{-15}}\ \mathrm{J}$$

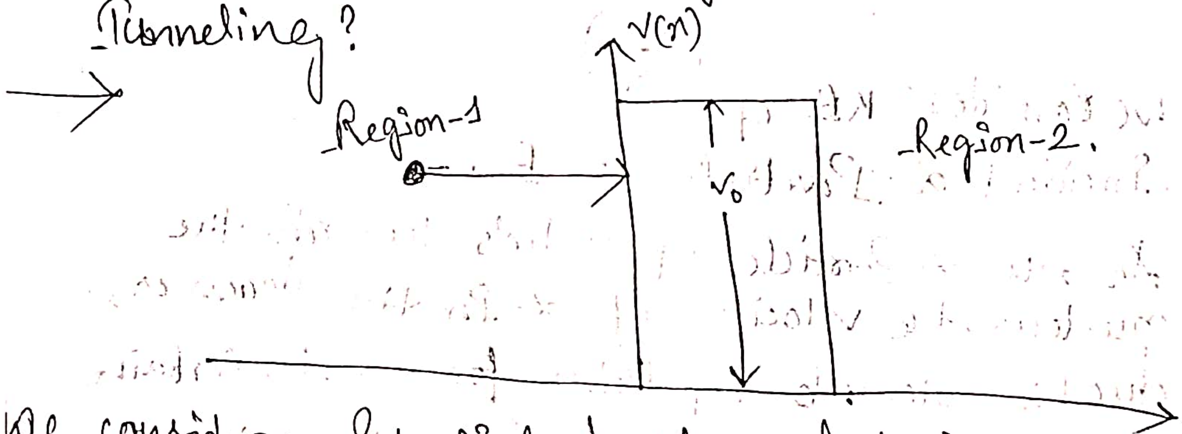
$$= 517.107 \times 10^{-14}\ \mathrm{J}$$

$$= 323.19 \times 10^{5}\ \mathrm{eV}$$

$$= 32.319\ \mathrm{MeV}$$

For the emittion of α-Particle the KE of α-Particle must be greater than equal to 32.319 MeV theoritically.

(*) What do you mean by Quantum mechanic Tunneling?



We consider a Potential barrier of hight V_0 as shown in the figure. A Particle with KE E incident on the Potential barrier.

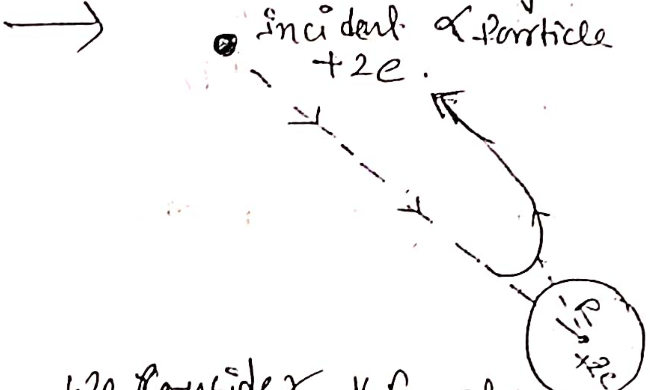
If $E < V_0$, then classically there is no Probability of Particle to appear in region-2

after crossing the Potential barrier.

But Quantum mechanically, there is always a Probability that, the Particle will Penetrate the Potential barrier and appear in a region-2. This Phenomenon is known as Quantum Mechanical tunnelling.

The emission of α-Particle from the nucleus is a proper example of quantum Mechanical tunneling.

⊛ Using Rutherford α-scattering Experiment find the radius of nucleus?



We Consider KE of Incident α-Particle $= E$.

As, the α-Particle approche's toward's the nucleus, the velocity of α-Particle decreases, due to coloumb repulsion force. At a certain point near the surface of nucleus, the velocity of the α-Particle is zero. As, Electro-Static field is conservative the total Energy should be const.

$$E = \frac{1}{4\pi\epsilon_0} \cdot \frac{2e \cdot Ze}{R}$$

$$E = \frac{2Ze^2}{4\pi\epsilon_0 R}$$

$$\Rightarrow \boxed{R = \frac{2Ze^2}{4\pi\epsilon_0 E}}$$

R is nearly equal to the radius of the nucleus.

this is an approximate expression of radius of nucleus from Rutherford α-scattering experiment.

(*) Find the radius of gold nucleus if the KE of α-particle is 8-MeV, in Rutherford α-scattering expt?

$Z_{gold} = 79$

$\rightarrow$

$$R = \frac{2\times 79\times (1.6)^2\times 10^{-38}}{8\times 10^6\times 1.6\times 10^{-19}} \times 9\times 10^{9}$$

$= \cancel{455}\ 284.4 \times 10^{-16}\ m$

$= 28.44\ fm.$

(2021)

(k) → The distance through which α-particle travel's in a specific medium before stopping to ionize the medium is known as Range of α-particle.

(f) → A subatomic particle having the same mass as one of the particles of ordinary matter but opposite electric charge and magnetic moment.

Ex — antiparticle of e^- → Positron (+ve)

" " Proton → antiproton (-ve)

" " neutron → antineutron (0)

(f) → The inreverse Process of β-decay is e^- capture, where the nucleus absorb's one of it's own orbital electron's if the absorbtion of electron from the K-shell then it is called K-capture.

(g) → The neutron no. of 1st nucleus is equal to Proton no. of 2nd nucleus and nutron no. of 2nd nucleus is equal to the Proton no. of 1st nucleus, then the nuclei is known as Mirror nuclei

Ex — F^{17}_{9}, O^{17}_{8}

p = 9, p = 8

n = 8, n = 9

(e) → The reaction rate is the no. of interacting taking place in one cubic centimeter per one second.

(f) → Internal conversion is a non radioactive, atomic decay process where an excited nucleus interacts electromagnetically with one of the orbital electrons of an atom.

β - Scattering

(*) What do you mean by β-decay / β-disintegration?
(ii) why β-Particle emitt's from nucleus?

→ (i) Due to unstability of nucleus both the Positron and electron are emitted from the radioactive nucleus, this phenomenone is known as β-disintegration.

The revese Process is electron capture, where the nucleus absob's one of it's own orbital electron's, if the absobtion of electron from the K-shell then it is called K-capture.

$$p \rightarrow n + \beta^{+} \text{(Positron)} + \nu \text{ (nutrino)}$$

$$n \rightarrow p + \beta^{-} \text{(electron)} + \bar{\nu} \text{ (antinutrino)}$$

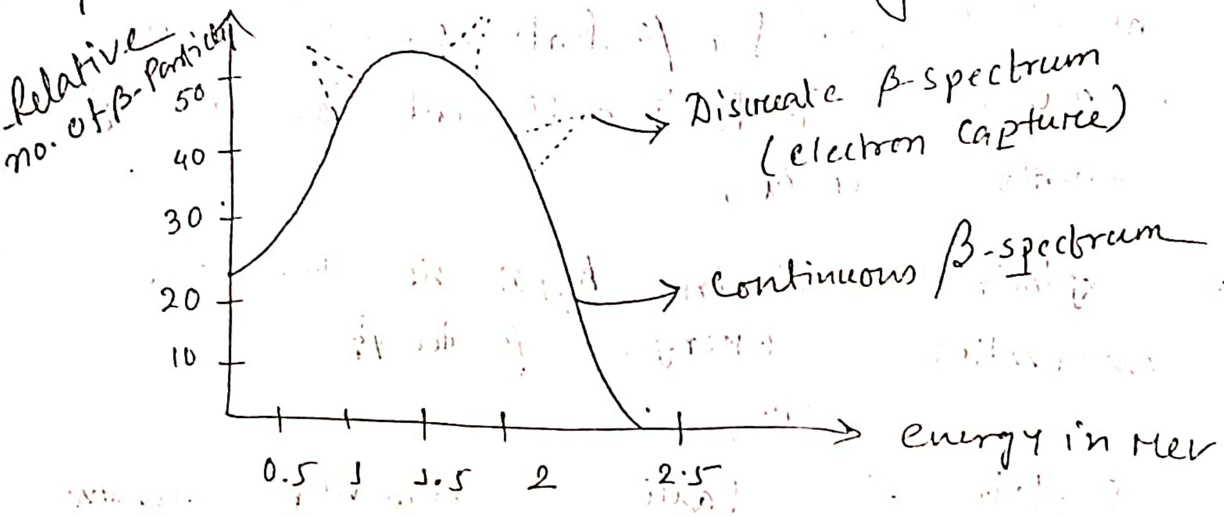
[electron capture] → $p + e^{-} \rightarrow n + \nu$ (nutrino)

(ii) for the stability of nucleus some time's nutron's are converted to Proton and some time's Proton's converted to nutron, when the β-Particle (Positron and electron) emitt's from that nucleus.

(*) Describe the nature of Energy spectrum of β-disintegration? write down the importance of β-ray Spectrum?

→ the energy of β-Particle's is studied with the help of β-ray spectrometer.

β-ray spectrometer can separate the β-Particle based on different energies of β-particle by using strong magnetic field. The General distribution of energy in a β-ray Spectrum is shown in the figure.



Characteristic of β-ray spectrum :- (Nature)

(i) The β-spectrum is continuous, having energies ranging from zero to a certain well defined limit known as end point energy (E_m) which is characteristics of the β-emitter.

(ii) The area between the β-spectrum and the energy axis is directly Proportional to the number of β-Particles.

(iii) There is a number of sharplines (Peaks) in the β- spectrum which are found to be very prominent on the photographic Plate.

(iv) Every continuous β- spectrum has a definite maximum height and Position of which depend on the nucleus emitting the Particles.

(v) There is definite upper limit or end Point of energy for β-Particles, emitted by the nucleus, which is different for different β- emitting nuclei.

Explain Neutrino hypothesis to explain Conservation of energy in β decay?

(or)

Explain How Pauli's neutrino hypothesis solve the conservation of Energy and momentum in β-decay?

→ Pauli's nutrino hypothesis : in nutrino hypothesis is assumed that, when a nucleus Emit's β -Particle, a nutron in a nucleus change's to a Proton and another Particle is also emitted along with β -Particle. If Only β -Particle is emitted from the nucleus, then all the β -Particle's for a given radio-a sample has same KE. But

actual measurement's show that only few β-Particle's emitted with maximum KE. From, β-decay sopectrum, the majority of β-Particle emitted with KE in between zero to a maximum value (End Point energy or Maximum Energy E_m). In this case the conservation of Energy and momentum, do not hold good for single Particle (β^- / β^+).

All this digicultis have been overcome by considering the existance of another type of Particle called nutrino, and it's anti particle antinutrino to be emitted simultaneously with β Particle. It's existance was first Predicted by Pauli on theoritical ground in (1930) and has been Experimentally confirmed in 1956. The β-Particle and a nutrino emitted from radioactive nucleus with a const. total energy = ~~difference~~ Q value of the reaction,

The different Possible energy of β-Particle arises from the sharing of total energy in between β-Particle and the nutrino. ~~Q value~~.

$$\boxed{Q\text{-value} = E_\beta + E_n}$$

$$n \longrightarrow p + \beta^- + \bar{\nu} \text{ (antinutrino)}$$

$$p \longrightarrow n + \beta^+ + \nu \text{ (nutrino)}$$

* Define thermal nutron?

→ when 1st moving nutron's have been slowed down until the average energy is equal to the 0.03 eV, Then the nutron's are called thermal nutron.

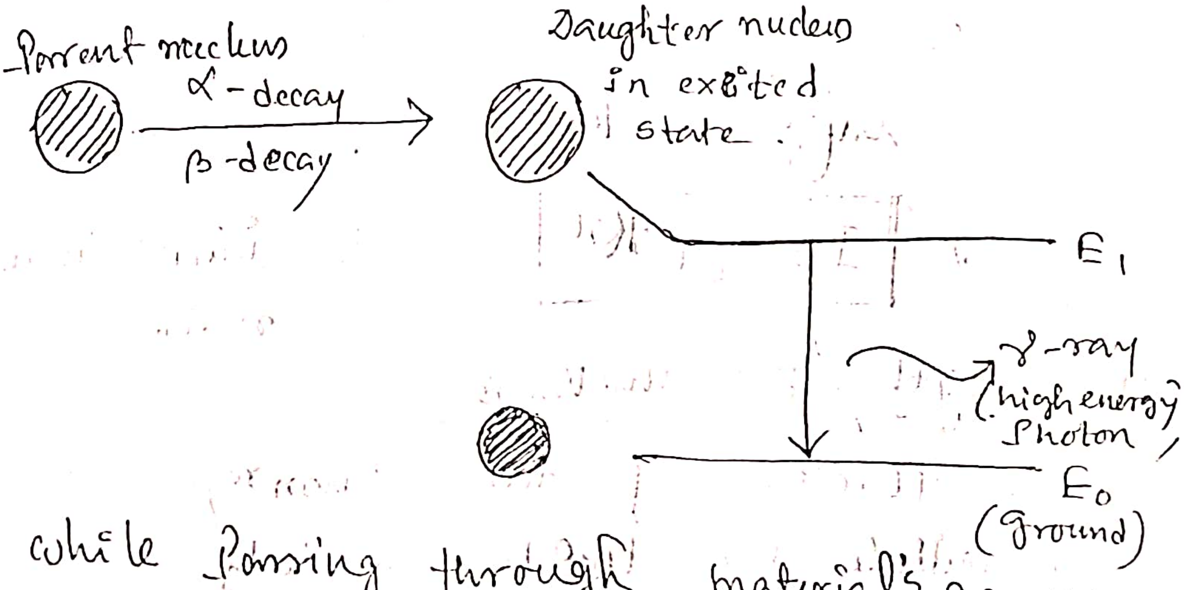
γ- Disintegration

(A) (i) How does the intensity of γ-ray changes when it interact's with matter, also defined the term's half thickness, radiation length / relaxation length?

(ii) Write down the origin of γ- decay?

→ (ii) After β- disintegration or α- disintegration the daughter nucleus may be in higher exited state. But the life time in exited state is very small and the daughter nucleus brought to ground state by emitting a High energy photon, which is known as γ-decay.

So, γ- decay is followed by α-disintegration and β-disintegration.

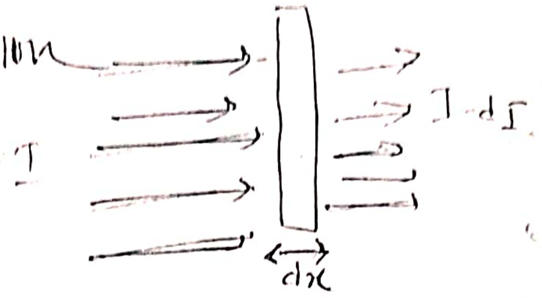


ii) While passing through material's gamma Photon's are either absorb or scattered from their path. Due to this, the intensity of γ-ray

is reduced as it passes through the material

Let

I = intensity of photon falling on a slab of material of thickness dx.



The decrease in intensity dI is proportional to initial intensity and thickness dx.

$\therefore dI \propto I$.

$dI \propto x$.

$dI \propto -I\,dx$

$\Rightarrow \frac{dI}{I} = -K\,dx$, μ / K = Proportional const. = absorption co-effici

Integrating both side w. in proper limit.

$$\int_{I_0}^{I} \frac{dI}{I} = -K \int_{0}^{x} dx$$

$$\Rightarrow \ln\left(\frac{I}{I_0}\right) = -Kx$$

$$\Rightarrow \boxed{I = I_0 e^{-Kx}}$$, I_0 = initial intensity = maximum intensity

Half length / Half thickness :-

The thickness of the medium required to reduce the intensity to half of the initial value of intensity is known as Half length / Half thickness.

at, $x = d_{1/2}$, $I = I_0/2$

$\therefore K d_{1/2} = 0.693$

$\Rightarrow \boxed{d_{1/2} = \frac{0.693}{K}}$

Radiation length / relaxation length :-

The thickness of the medium to require, which reduces the intensity of γ-ray to $1/e$ times of initial intensity, is known radiation length / relaxation length.

at, $x = \infty$, $I = \frac{I_0}{e}$

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Q) mention different processes through which γ-ray's are absorbed or scattered, by the material.

→ There are mainly three process, through which γ-photon's loss energy, while traveling through the medium —

(i) Photo electric effect :- In photo electric effect, γ-photon make collision with bound electron of an atom and in this process the whole photon energy is transfered to that electron. If the incident photon energy

is sufficient then, after the collision, the electron is ejected from the atom, which is known as photo electron.

According to Einstine photoelectric equ^n, the energy of ejected photoelectron is given by.

$$\frac{1}{2} m V_{max}^2 = h\nu - w_0,$$

$h\nu$ = incident radiation energy

w_0 = work fun^n

(ii) Compton effect :-

In compoton effect, Photon is scattered by free electron at rest, it is an elastic scattering Process in which the incident photon's transfered a portion of its energy to the electron. after the collision, the photon is scattered by an angle ϕ, the electron ~~reqoil's~~ at angle θ. In this condion K.E gain by electron,

$$E = h\nu \left[\frac{\frac{h\nu}{m_0c^2}(1-\cos\phi)}{1+\frac{h\nu}{m_0c^2}(1-\cos\phi)} \right]$$

(iii) Pair Production :- In this Process γ- Photon's with energy greater than 1.02 MeV is converted to pair of electron and positron in presence of highly dense medium (nucleus)

γ-photon $\xrightarrow[\text{medium}]{\text{High Density}}$ electron + Positron
(e^-) (e^+)

Q (i) Explain, why, the minimum energy require for Pair Production of is 1.02 MeV.

(ii) Explain, why Pair Production is not Possible in Vaccume.

→ (i) In Pair Production γ-photon is converted to electron - Positron Pair.

γ-ray ⟶ electron + Positron
(e^-) (e^+)

The minimum energy of γ-ray =

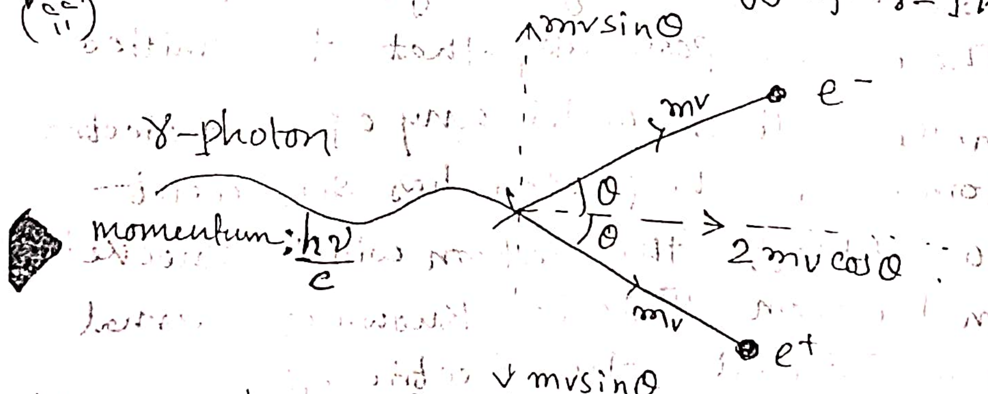
Rest mass energy of e^- + Rest-mass energy of e^+

= 0.51 MeV + 0.51 MeV

= 1.02 MeV.

That is why minimum energy of γ-photon for

(ii)



We consider a γ-photon with energy $h\nu$.

The momentum of photon $= \frac{h\nu}{c}$

Using momentum Conservation along x-axis.

$$\frac{h\nu}{c} = mv\cos\theta + mv\cos\theta$$

$$\Rightarrow h\nu = 2mcv\cos\theta = (2mc^2)\frac{v}{c}\cos\theta$$

$\Rightarrow$ energy of γ-ray $= \left(\text{energy of } e^- + e^+\right) \times \frac{v}{c}\cos\theta$ $\quad$ mc^2 = energy of electron/Positron.

$\longrightarrow$ (1) $\quad 2mc^2$ = energy of $e^- + e^+$

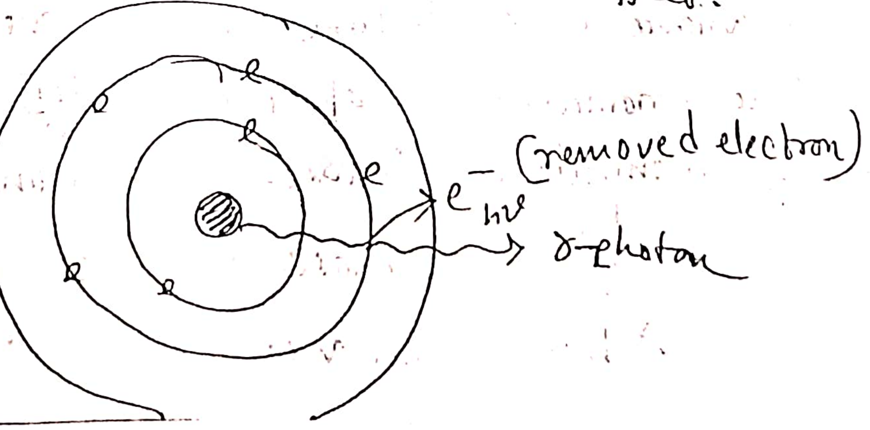
The maximum value of $\cos\theta = 1$ and v/c always less than 1.

$\therefore$ energy of γ-ray < [energy of e^- + Positron(e^+)]

For any natural Process the momentum and mass energy should be consumed Simultaneously. That is why Pair Production is not Possible in free Space.

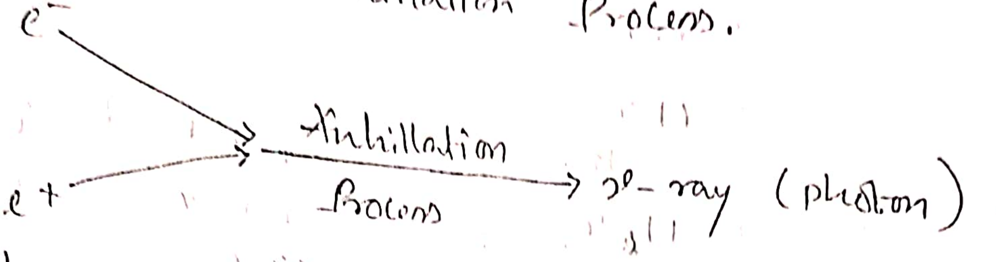
(*) What do you mean by internal conversion or internal photoelectric effect.

$\longrightarrow$ After α-disintegration or β-disintegration the daughter nucleus may be in excited state, but the Life time of a nucleus in excited state is very small. when an excited nucleus comes to ground state by emitting high energy Photon (γ-ray). Their is a possibility that the emitted Photon make collision with any of the electron of the atom. If the photon has sufficient amount of energy the electron will be knocked out from the atom. This is known as internal conversion or internal photoelectric effect.



(*) What do you mean by Anhillation Process.

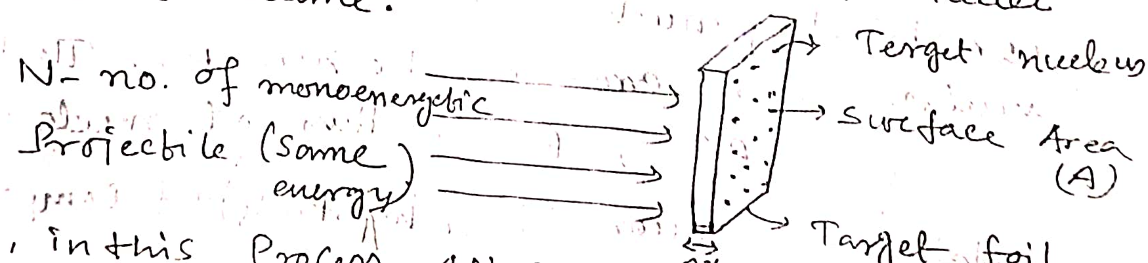
→ When Particle and antiparticle meet with each other they destroy each other's mass and converted the mass into Photon (γ-ray). This Process is known as Anhillation Process.



(*) What do you mean by nuclear cross section. Write down the unit of nuclear cross section.

→ Nuclear reation cross-section is one of the important parameter in nuclear reaction. It is a quantative measure of the Probability occurance of a nuclear reaction.

Let a parallel beam of N number of mono energetic Particles be incident Per unit time normally on a terget foil T (containing terget nuclei). The surface area of the foil is A and thickness Δx, heaving n number of nuclei Per unit volume.



Let, in this Process ΔN number of nucleus undergoes nuclear reaction. ΔN is proportional to —

(i) the intensity of incident Projectile.

(ii) the number of terget nuclei in the foil.

$\therefore \Delta N \propto \frac{N}{A}$ $\left[I = \frac{N}{A} = \text{intensity of Projectile} \right]$

$\Delta N \propto (A \Delta x) n$

$\therefore \Delta N \propto n N \Delta x$.

$\Rightarrow \Delta N = \sigma N n \Delta x$.

$\Rightarrow \Delta N = \sigma N \frac{n_0}{\Delta x A} \Delta x$

$\Rightarrow \Delta N = \sigma N_A n_A$ $\left[n_A = \text{no. of target nucleus per unit area} \right]$

$$\boxed{\sigma = \frac{\Delta N}{N n_A}}$$

From the above equn the dimension of σ is $[L^2]$ similar to the dimension of area. This why σ as teremed as cross-section.

The Probability of a nucleaar reection when a single Particle (N=1) Fass ona single target nucleus Pre ______ Per unit area ($n_A = 1$), is given by nuclear reaction crosssection.

The unit of nuclear cross-section barn.

$1 \text{ barn} = 10^{-28} m^2$

Geomatrically nuclear cross-section equal to two dimension disc area of the nucleus. That is

$\sigma = \pi R^2$, R = radius of nucleus.

(*) Explain (Bhor's theory / bhor hypothesis) of compound nucleus:

→ when an incident Projectile x enters into a target nucleus X to produce a nuclear reaction, a highly excited intermediate state c^*

is formed which finally decays into the Product nucleus Y and another Particle y.

$$X + x \longrightarrow C^* \longrightarrow Y + y$$

Inside the nucleus X, the Projectile x rapidly dissipates its energy and merges with the closely packed nucleons.

Remaining Part in Picture